Regional Operational Plan SF.3F.2014.07

Operational Plan: Broad Whitefish: Determining Spawning Locations of Minto Flats Summer Resident Fish and Summer Locations of Tanana River Spawning Fish

by

Andrew D. Gryska

March 2015

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN SF.3F.2014.07

BROAD WHITEFISH: DETERMINING SPAWNING LOCATIONS OF MINTO FLATS SUMMER RESIDENT FISH AND SUMMER LOCATIONS OF TANANA RIVER SPAWNING FISH

by

Andrew D. Gryska

Alaska Department of Fish and Game, Sportfish Division, Fairbanks

Alaska Department of Fish and Game
Sportfish Division

March 2015

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: http://www.adfg.alaska.gov/sf/publications/

Andrew D. Gryska,
Alaska Department of Fish and Game,Sportfish Division,
1300, College Road, Fairbanks, Alaska 99701

This document should be cited as:
Gryska, A. D. 2014. Broad Whitefish: Determining spawning locations of Minto Flats summer resident fish and summer locations of Tanana River spawning fish. Alaska Department of Fish and Game, Regional Operational Plan ROP.SF.3F.2014.07, Fairbanks.

SIGNATURE PAGE

Project Title:	Broad Whitefish: Determining spawning locations of Minto Flats summer resident fish and summer locations of Tanana River spawning fish
Project leader(s):	*Andrew D. Gryska*
Division, Region, and Area	*Sportfish, Region III, Upper Tanana*
Project Nomenclature:	
Period Covered	July 1, 2014 – May 31, 2018
Field Dates:	May 21, 2013 – October 15, 2016
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	Andrew Gryska		3/4/15
Biometrician	Pat Hansen	Pat Hansen	5/5/14
Research Coordinator	Matt Evanson		3/4/15
Regional Supervisor	Don Roach		3/5/15

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The primary objective of this investigation is to identify where Minto Flats broad whitefish spawn and to determine if the Tanana River spawning stock is comprised solely of Minto Flats broad whitefish or of multiple summer feeding stocks. Spawning reaches, over winter locations, and summer feeding areas will be identified based on the geographic distribution of locations of radiotagged fish during these periods. In Minto Flats, 40 broad whitefish will be tagged during early summer, and an additional 40 broad whitefish will be tagged in the Tanana River during late fall. Over the next 3 years, locations of radio tagged fish will be determined by periodic aerial surveys.

Key words: broad whitefish, *Coregonus nasus,* Minto Flats, Tanana River, radiotelemetry.

PURPOSE

The Tanana River is a major tributary of the Yukon River in Alaska. Five coregonid species have been documented in the drainage including; broad whitefish *Coregonus nasus*, humpback whitefish *Coregonus pidschian*, sheefish *Stenodus leucichthys* (inconnu), least cisco *C. sardinella*, and round whitefish *Prosopium cylindraceum*. Broad whitefish support important subsistence and personal use fisheries within the Tanana Drainage with the more prominent fisheries occurring within the vicinity of Fairbanks and the villages of Minto and Nenana (Townsend and Kepler 1974; Shinkwin and Case 1984). These fisheries occur primarily within Minto Flats wetlands complex and its interconnected waterbodies including the Chatanika, Tolovana, and Tanana rivers (Figure 1).

Broad whitefish are known to use Minto Flats during the summer for feeding, however, no information on the distribution of these fishes the remainder of the year area is available. Humpback whitefish also feed in Minto Flats during the summer, and they are known to spawn in the Chatanika River (Kepler 1973; Fleming 1996; Dupuis 2010), as well as the Tanana River near Fairbanks based on a recent radio telemetry (DuPuis 2010). Broad whitefish have never been documented spawning in the Chatanika River (Towsend and Kepler 1974; Brown et al. 2012). Adult broad whitefish were suspected of vacating Minto Flats during August for spawning areas based on diminishing catches and not observing them in the Upper Tolovana or Chatanika rivers (Kepler 1973 and Towsend and Kepler 1974). It is unknown where they go, but between late August and mid-October, broad whitefish have been intercepted by fish wheels near Nenana.

Several broad whitefish captured near Nenana were radiotagged and located during their spawning period near Fairbanks in the Tanana River (Brown et al. 2012), and one of the radio tagged fish was recorded at a tracking station on the Koyukuk River the following summer (R. J. Brown, Fisheries Biologist, USFWS, Fairbanks, AK, pers. Comm.). In addition, electrofishing surveys of the Tanana River spawning areas during this period have resulted in catches of numerous adult whitefish in spawning condition including broad whitefish. Although these observations indicate broad whitefish likely spawn in the area, it is not known from where these broad whitefish originate. Based on the evidence above, it is believed broad whitefish from Minto Flats spawn in the Tanana River near Fairbanks, but there has been no direct evidence to date. It is also possible that spawning Tanana broad whitefish are composed of fish from other summering areas such as Lake Minchumina, Fish Lake, or numerous other areas of the Yukon River (Figure 2).

Whitefish exhibit large variation in life history characteristics and many basic life-history questions remain unanswered in Alaska, particularly for broad whitefish. The lack of information regarding the life history of broad whitefish hinders the ability of fisheries

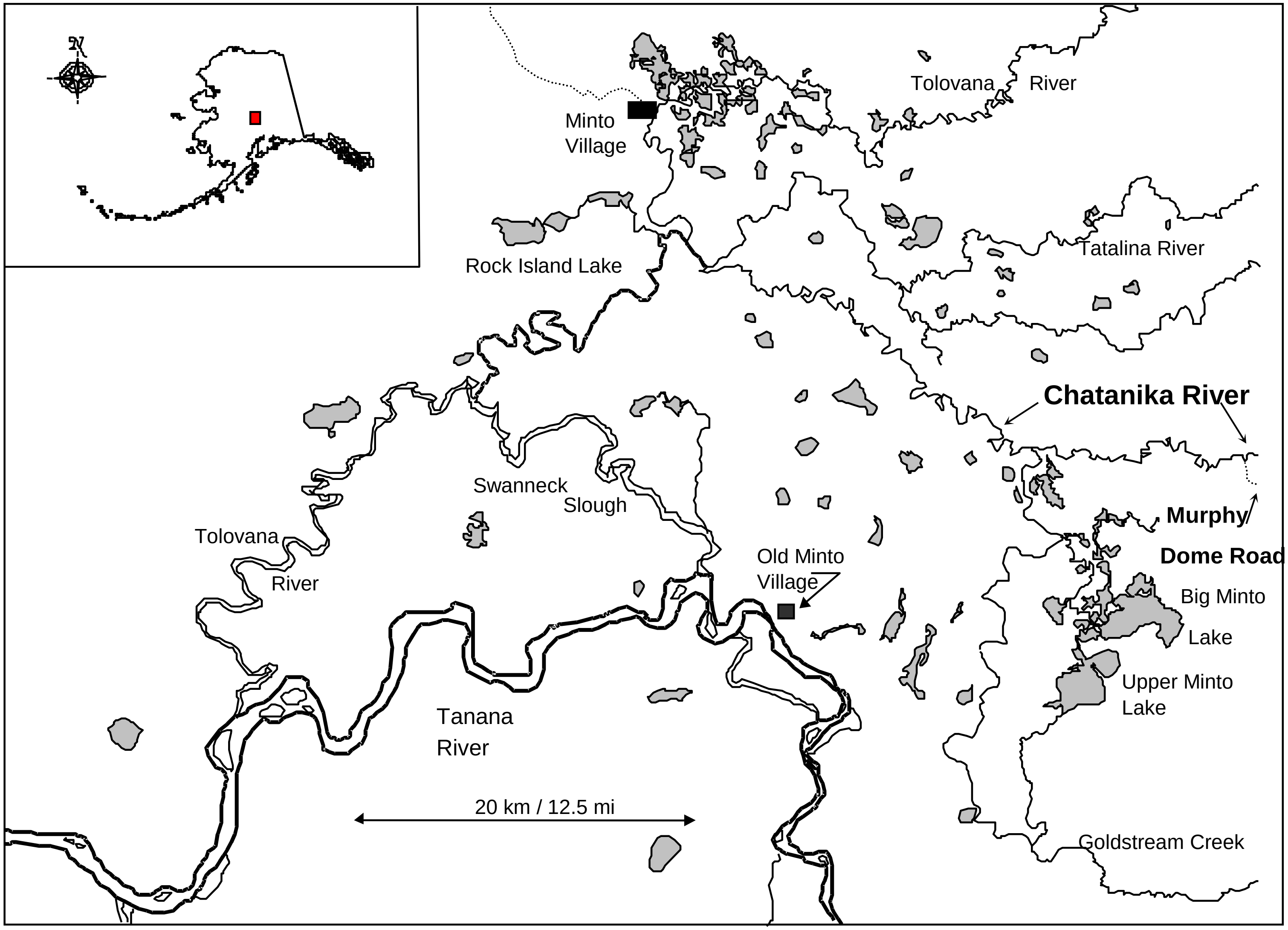

Figure 1.–Map of Minto Flats and the lower portions of the Chatanika, Tolovana, and Tatalina rivers.

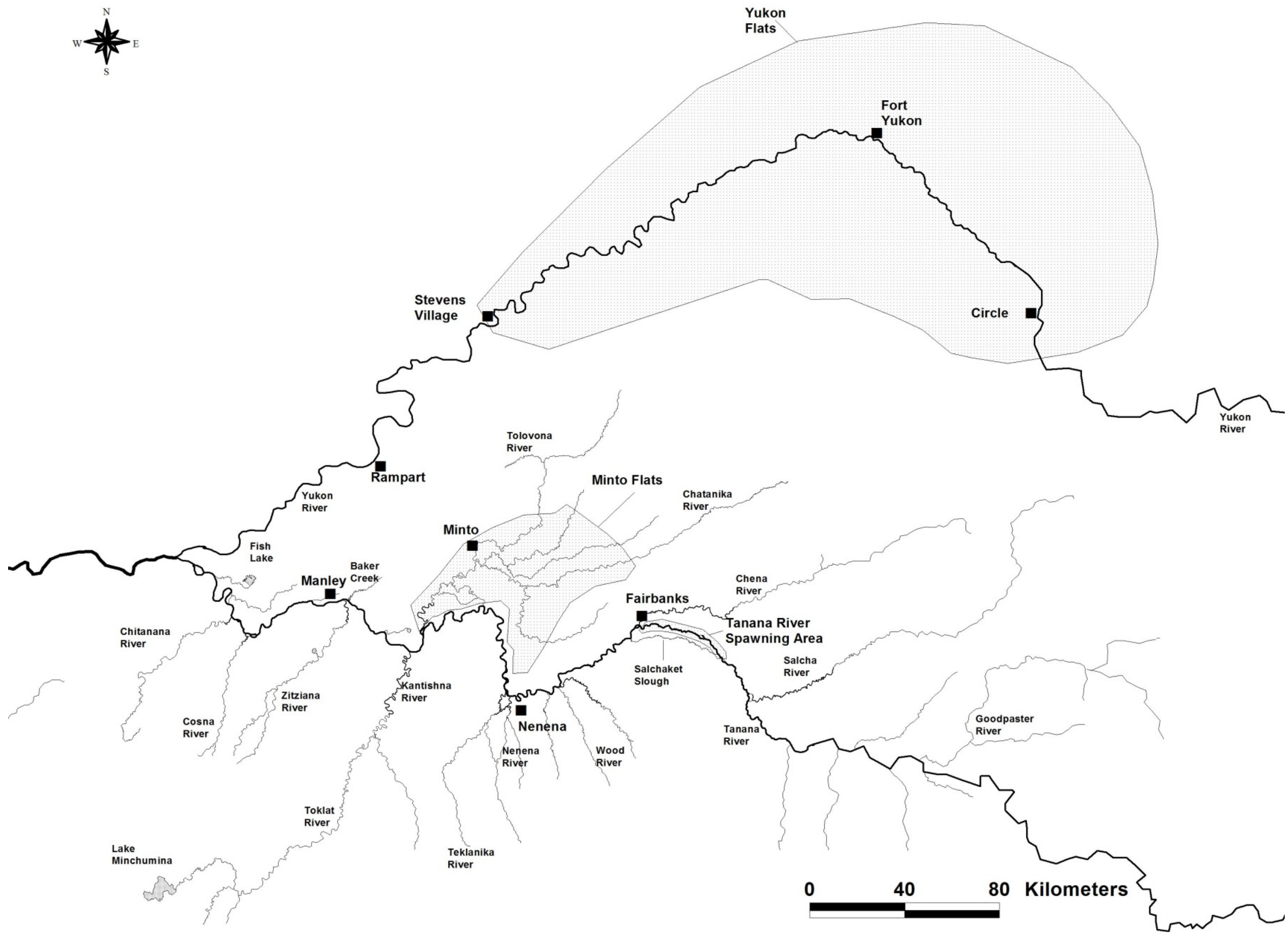

Figure 2.–The Minto Flats summer resident area and the Lower Tanana River and Middle Yukon River spawning areas.

managers' to manage exploitation and mitigate development. Development in the greater Fairbanks area will continue to increase and, for example, the construction of a new railroad bridge over the Tanana River will require significant extraction of riverbed gravels. The location of this bridge is in close proximity (2–10 km upstream) to spawning aggregations of humpback whitefish and sheefish, and potential spawning areas for broad whitefish may be in similar proximity (Dupuis 2010, Brown 2012, Gryska *In prep*). Due to potential threats affecting the health of broad whitefish populations, it is important to identify essential seasonal habitats and their proximity and timing, relative to exploitation and development. In addition, any future attempt to characterize abundance of a population requires identifying discrete populations and suitable locations and times to execute procedures to estimate abundance.

To provide insights about the life history of broad whitefish in the Tanana River drainage, 40 radio transmitters will be implanted in pre-spawning broad whitefish captured in the Minto Flats during early summer, and 40 radio transmitters will be implanted in spawning broad whitefish captured in the Tanana River spawning area during late fall. Over the next three years, radio-tagged broad whitefish will be located periodically during important seasonal periods (summer, spawning, and winter) so that spawning area(s) of Minto Flats may be identified, and the stock composition of Tanana spawners may be partially determined.

OBJECTIVES

The objectives are to:

1. Estimate the proportion of broad whitefish ≥450 mm FL residing in the Minto Flats wetlands complex during early summer that spawn in the Tanana River. The estimate will be within 17.5 percentage points of the true value 90% of the time.
2. Estimate the proportion of broad whitefish ≥450 mm FL that spawn in the Tanana River that reside in the Minto Flats wetlands complex during summer. The estimate will be within 15 percentage points of the true value 90% of the time.
3. Describe the seasonal distributions of broad whitefish ≥450 mm FL that reside in the Minto flats during summer with an emphasis on documenting spawning and over winter areas.
4. Describe the seasonal distributions of broad whitefish ≥450 mm FL that spawn in the Tanana River during late fall with an emphasis on documenting overwinter and summer resident areas.

STUDY DESIGN

STUDY AREA

The sample areas encompass the Minto Flats (1,867 sq. km) during early summer and a portion of the Middle Tanana River (39 km between the Chena River mouth and the beginning of Salchaket Slough) during late fall (Figure 2). The telemetry survey area could be quite large. Broad whitefish may potentially be found throughout the entire Lower Yukon drainage from the mouth of the Yukon River to Circle. For example, a broad whitefish radiotagged near Nenana was picked up by a tracking station on the Koyukok River the following year (R. J. Brown, Fisheries Biologist, USFWS, Fairbanks, AK, pers. Comm.). It is known that broad whitefish migrate to the Alatna River and Yukon Flats to spawn (Carter 2010, Brown 2009). In addition, 80% of broad whitefish sampled in the Tanana River near Nenana had otolith chemistry indicating anadromy (Brown et al. 2007). The search area for this study will primarily focus on the Middle and Lower Tanana River, Minto Flats, Lake Minchumina, and the Yukon Flats (Figure 2). Other areas will be searched as time allows; however, it is recognized that the potential search area is far too large to be comprehensively searched.

SAMPLING DESIGN

Broad whitefish will be captured with tangle and fyke nets in the Minto Flats during early summer (mid-May to mid-June) and with electrofishing boats in the Tanana River late fall (early October). The early summer sample period was selected so broad whitefish would be handled when the water temperature was still cold (<14°C). Warm water is stressful, and by avoiding it, it is expected that healing and survival will be enhanced. The late fall sample period was selected so that spawning fish would be targeted. In addition, the fall water temperatures will be cold. To ensure that most fish sampled are mature, only fish ≥ 450 mm FL will be radiotagged (Harper et al. 2007; Carter 2010). Most, if not all, fish captured in Tanana River spawning area are expected to be mature.

Efforts will be made to distribute radio tags throughout each sample area to guard against potential differences in spawning area destination or summer feeding area origination (Appendix A1). Data related to movements and spawning locations will be collected using a combination of aerial tracking surveys and boat surveys. Tracking surveys will be conducted from summer 2014 through the fall of 2017.

SAMPLE SIZE

Objective 1 - Proportion of summer Minto Flats fish spawning in the Tanana River

If we tag 40 broad whitefish in Minto Flats during the summer and we assume a 20% mortality rate during the summer due to tagging and natural mortality (Brown 2009; Harper et al. 2009), we would have 32 working tags going into the first fall spawning period of which 70% (22 fish) will likely spawn (Brown 2009). Also assuming worst case scenario that 50% of the spawning radiotagged fish migrate to the Tanana River we can expect our estimate to be within 17.5 percentage points of the true value 90% of the time (binomial proportion, $n = 22$, $p = 0.5$).

Objective 2 - Proportion of spawning Tanana River fish summering in Minto Flats

If we tag 40 broad whitefish in the Tanana River during the fall and we assume a 20% tagging and natural mortality rate, (Brown 2009; Harper et al. 2009) we would have 32 working tags going into the summer. Also assuming worst case scenario that 50% of the fish that spawned in the Tanana River fish migrate to Minto Flats we can expect our estimate to be within 14.5 percentage points of the true value 90% of the time (binomial proportion, $n = 32$, $p = 0.5$).

To mitigate some of the potential problems associated with a relatively small sample size, several actions will be taken to reduce potential loss. Only broad whitefish ≥450 mm FL will be tagged because it is expected that they are mature and will spawn at least once during the course of the 3-year study. Handling mortality will be reduced by sampling when the water is cold, just after break-up and just before freeze-up. Our sampling in Minto Flats will be spread out over a large area in attempt to subject most resident fish to some non-zero probability of capture (Appendix A). Our sampling in the Tanana River will be spread out over time in the event the arrival of broad whitefish into spawning grounds varies by summer resident location. Periodic aerial surveys will be utilized to monitor timing and direction of migrations to make intuitive decisions about additional search areas. A single frequency will be used to minimize scan time so that flying speeds of surveys in a Cessna 180 can increase to cover more area.

SAMPLE METHODS

Fish Capture

To capture broad whitefish, different capture techniques will be utilized in each sample area. In Minto Flats, tangle nets (18 m x 3 m, 5-cm stretch mesh) and fyke nets will be used. Gill nets will be set for a minimum of 1 hour at each sample location and carefully monitored. When a fish becomes entangled, it will be immediately removed from the net, identified and measured for length. Fyke nets will be set at interception points (e.g. small sloughs leading to lakes) and will be checked each morning, at a minimum.

In the Tanana River, an electrofishing boat will be used to capture fish. The boat will be equipped with a pulsed-DC variable-voltage pulsator (Coffelt Model VVP-15) powered by a 5,000 watt single-phase generator. The electrical output (voltage, amperage, and cycle) will be adjusted based on observed responses of shocked fish. To minimize fish mortality and injury, voltage will be adjusted (250–300 V) to keep amperage constant (i.e., between 2 and 4 A) and avoid using electrical output values that cause fish to roll over and become paralyzed (M. Holliman, University of Alaska-Fairbanks; personal communication). Initially, settings on the pulsator will be set at 50% duty cycle and 30 Hz.

One to 5 broad whitefish will be tagged in any given daily sample location. All incidentally captured fish species will be handled immediately, identified, measured for length, and released. Captured broad whitefish ≥450 mm FL will be retained and immediately tagged with a radio transmitter.

Radiotelemetry

Radio tags will be surgically implanted following the basic surgical methods detailed by Brown (2006) and Morris (2003). Because fish in Minto Flats will be captured 4 to 5 months prior to spawning, sex and spawning condition will be difficult to identify. Therefore, only broad whitefish ≥450 mm FL will be radiotagged because it is quite likely they are mature. Nonetheless, an attempt to sex fish will be conducted by inspecting the gonads through the incision. Fish captured in the Tanana River should all be mature and gender should be identifiable, externally by extrusion of eggs and milt and internally by visual inspection through the incision.

Radio tags will operate on 1 frequency with individual transmitters digitally coded for identification. Radio tags will be operational for 3 to 4 years and will transmit continuously 24 hours per day with a signal emitted every 4 sec. Radio tags will be located during periodic aerial surveys and boat surveys. During summer, surveys will occur about once a month, while during the spawning season, surveys will occur about once a week. During winter (November–March), surveys will occur 3 times (early, middle, and late).

To identify likely spawning areas, suspected reaches will be surveyed in the Tanana and Yukon rivers and over other suspected areas, as indicated by late summer tracking flights. During the spawning season (late September through late October), flights will occur about once a week. These flights will continue until almost all spawning broad whitefish (e.g. 95%) are observed making pronounced downstream migrations after the spawning period. The geographic distribution of broad whitefish during the two or more surveys when they are at their farthest upstream points of migration will be interpreted as the approximate geographic range of the spawning reach. Boat surveys will be conducted opportunistically when navigating the Tanana River near Fairbanks during early October when capturing broad whitefish for tagging.

DATA COLLECTION AND REDUCTION

During the fieldwork, data will be recorded into all-weather field notebooks and field data forms. For each broad whitefish captured, data collected will include:

1) measurement of fish length to the nearest 5 mm FL;
2) sex (if possible);
3) location (river-kilometer and GPS coordinate);
4) radio tag frequency and code;
5) capture gear; and,
6) date.

In addition, documentation of all other fish captured will be recorded. Incidentally caught species will not be tagged and data recorded will include all the above except tagging data.

During each aerial or boat tracking survey, data collected for each fish will include frequency, code, latitude, longitude, and a general description of its location (e.g. approximately 1 km upstream from Nenana River).

Following all fieldwork, data will be transcribed into an EXCEL workbook. Specifically, an EXCEL worksheet will be made with column headings related to the field data form and comments. A brief project description in a text box will be provided for added clarity. Coordinates will be plotted on USGS maps (represented in Alaska NAD27 Datum) using ArcGIS software after converting Lotek data with Franson Coordtrans software from WGS84 Datum to Alaska NAD27 Datum. Final copies of the Excel and ArcGIS files will be provided with the completed report when it is submitted for review to be archived in the Sport Fish Division Docushare website. The file name and directory location will be presented in the final report.

DATA ANALYSIS

Objective 1 - Proportion of summer Minto Flats fish spawning in the Tanana River

The proportion of broad whitefish that reside in the Minto Flats wetlands complex during early summer that spawn in the Tanana River will be estimated as a binomial proportion:

$$\hat{p}_t = \frac{n_t}{n_M}; \qquad (1)$$

where:

$n_t =$ number of broad whitefish radio tagged in Minto Flats determined to have spawned in the Tanana River; and,

$n_M =$ the number of broad whitefish radio tagged in Minto Flats with working radio tags at the time of spawning.

The variance of the proportion will be estimated by (Cochran 1977):

$$\mathrm{var}(\hat{p}_t) = \frac{\hat{p}_t(1 - \hat{p}t)}{n_M - 1}, . \tag{2}$$

Potential spatial and temporal bias will be examined using chi-square tests of independence. To test for spatial bias, Minto Flats will be divided into 3 general areas: the Lower Tolovana River (downstream of the Chatanika mouth), the Upper Tolovana River (upstream of the Chatanika mouth), and the Big Minto Lake and Goldstream Creek. The proportion of radio tagged fish from each area that spawn in the Tanana River will be compared. To test for temporal bias, the sampling period will be divided into 3 relatively equal time periods (early, middle, and late) and the proportion of radio tagged fish from each temporal strata that spawn in the Tanana River will be compared.

Objective 2 - Proportion of spawning Tanana River fish summering in Minto Flats

The proportion of broad whitefish that spawned in the Tanana River that reside in the Minto Flats wetlands complex during summer will be also be estimated as a binomial proportion:

$$\hat{p}_m = \frac{n_m}{n_T}; \tag{3}$$

where:

$n_m =$ number of spawned broad whitefish radio tagged in the Tanana River located in the Minto Flats wetlands complex during summer; and,

$n_T =$ number of spawned broad whitefish radio tagged in the Tanana River with working radio tags during summer.

The variance of the proportion will be estimated by (Cochran 1977):

$$\mathrm{var}(\hat{p}_m) = \frac{\hat{p}_m(1 - \hat{p}_m)}{n_T - 1}, . \tag{4}$$

Potential temporal bias will be examined using a chi-square test of independence. The sampling period on the Tanana River will be divided into 3 relatively equal time periods (early, middle, and late) and the proportion of radio tagged fish from each temporal strata that are located in the Minto Flats wetlands complex during summer will be compared.

Objectives 3 and 4 - Describe the seasonal distributions of all radiotagged broad whitefish

Data analysis will consist of plotting locations of radiotagged broad whitefish on maps and constructing a data profile of each radio-tagged fish. Maps will be constructed using ArcGIS software, and will depicting locations of interest: tagging, summer residence, spawning, and over-winter residence. Final fates of each tagged fish will be fully determined by project completion.

Profiles will include all relevant data collected from each radio-tagged fish: length at capture, sex, capture location, GPS location during each survey, time past tracking station, and the status (fate) of each fish during each survey. Fates will be determined from a combination of information collected during aerial and boat tracking surveys (Table 1). Because broad whitefish are highly migratory, mortality can be easily inferred if a broad whitefish is located more than once and fails to move a significant distance (5 km) over a period of one month or greater. The unknown fate is usually a temporary designation for radiotagged fish for which there is insufficient data to determine if the fish was alive or not. For example, if a fish is tagged during May and not located again until spawning surveys amongst a spawning aggregation during the following three years, then it would have been temporarily assigned an unknown fate until found spawning, when it would be designated a spawner. At the end of the 3-year study, final fates will be determined.

Other fish species

While attempting to capture broad whitefish, it is expected a number of other fish will be captured, and information about those catches will be recorded for future reference. For this project, analysis of this information will be limited to summary tables. The tables will indicate the date, location, gear type, and number of each species captured. In addition, the size range and mean size of each species at each sample location and date will be presented.

Table 1.–List of possible fates of radio-tagged broad whitefish.

Fate	Description
Unknown (U)	A fish that that may be dead or alive but its status cannot be determined because there was insufficient data (e.g., a fish was not located or moved very little).
Mortality (M)	A fish that dies in response to tag implantation, fishing, or natural causes.
Spawner (S)	A fish that is alive and displayed an obvious migration pattern towards a known or typical spawning area in conjunction with other radio tagged broad whitefish.
Non-Spawner (NS)	A fish that is alive and is located at least once during the summer, but did not display an obvious migration pattern toward a known or typical broad whitefish spawning habitat in conjunction with other radio tagged broad whitefish.

SCHEDULES AND REPORTS

A Fisheries Data Series (FDS) Report will be submitted to the research coordinator by May 1, 2018. This report will summarize all capture and tagging information from summer 2014 and all telemetry data from aerial survey flights, receiving stations, and boat surveys. Probable dates for sampling activities are summarized below.

Date	Activity
May 1–14, 2014	Mobilization
May 19 –June 13, 2014	Sampling
October 1–17, 2014	Sampling
July, 2014– October 2017	Periodic Flights
November 2017	Analysis
January 2018	Draft Report
May 2018	Final FDS Report

RESPONSIBILITIES

PROJECT STAFF AND PRIMARY ASSIGNMENTS

Andrew Gryska, *Fisheries Biologist II*. Project Leader.
Responsible for supervision of all aspects of this project, data analysis, managing the project budget, and writing the final report.

Pat Hansen, *Biometrician IV*. Assist with project design and data analysis.

Klaus Wuttig, *Fishery Biologist III.* Final report editing and project support and all aspects of field work.

Matt Albert, *Fish & Wildlife Technician III*. Crew leader. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Brian Collyard, *Fish & Wildlife Technician III*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Rick Queen, *Fish & Wildlife Technician II*. Mobilization, day-to-day project tasks, all aspects of field work, and demobilization.

Audra Brase, *Fishery Biologist III.* All aspects of field work.

Tim Viavant, *Fishery Biologist III.* All aspects of field work.

Erik Anderson, Education Associate. All aspects of field work.

REFERENCES CITED

Brown, R. J. 2006. Humpback whitefish *Coregonus pidschian* of the upper Tanana River drainage. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 90, Fairbanks.

Brown, R. J., N. Bickford, and K. Severin. 2007. Otolith trace element chemistry as an indicator of anadromy in Yukon River drainage Coregonine fishes. Transactions of the American Fisheries Society 136:678-690.

Brown, R. J. 2009. Distribution and demographics of whitefish species in the upper Koyukuk River drainage, Alaska, with emphasis on seasonal migrations and important habitats of broad whitefish and humpback whitefish. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 104, Fairbanks.

Brown, R. J., C. Brown, N. M. Braem, W. K. Carter, N. Legere, and L. Slayton. 2012. Whitefish and whitefish fisheries in the Yukon and Kuskokwim river drainages in Alaska: a review with recommendations for future research. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Number 2012-4, Fairbanks.

Carter, W. K. 2010. Life history and spawning movements of broad whitefish in the middle Yukon River. Master's thesis, University of Alaska Fairbanks.

Cochran, W. G. 1977. Sampling techniques, *third edition.* John Wiley and Sons, New York.

Dupuis, A. W. 2010. Reproductive biology and movement patterns of humpback whitefish and least cisco in the Mint Flats-Chatanika River complex, Alaska. Master's thesis, University of Alaska Fairbanks.

Fleming, D. F. 1996. Stock assessment and life history studies of whitefish in the Chatanika River during 1994 and 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-19, Anchorage.

Gryska, A. D. In prep. Preliminary report on the spawning locations of Tanana River summer resident sheefish. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Harper, K., F. Harris, S. J. Miller, and D. Orabutt. 2007. Migratory behavior of broad and humpback whitefish in the Kuskokwim River, 2006. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Number 2007-11, Kenai

Harper, K., F. Harris, S. J. Miller, and D. Orabutt. 2009. Migration timing and seasonal distribution of broad whitefish, humpback whitefish, and least cisco from Whitefish Lake and the Kuskokwim River, Alaska, 2004 and 2005. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 105, Kenai.

Kepler, P. P. 1973. Population studies of northern pike and whitefish in the Minto Flats Complex with emphasis on the Chatanika River. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1972-1973, Project F-9-5, 14 (G-II-J), Juneau..

Morris, W. 2003. Seasonal movements and habitat use of Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*), and broad whitefish (*Coregonus nasus*) within the Fish Creek drainage of the National Petroleum Reserve-Alaska, 2001-2002. Technical Report No. 03-02, Alaska Department of Natural Resources, Fairbanks, Alaska.

Shinkwin, A., and M. Case. 1984. Modern foragers: wild resource use in Nenana Village, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 91, Fairbanks.

Townsend, A. H. and P. P. Kepler. 1974. Population studies of northern pike and whitefish in the Minto Flats Complex with emphasis on the Chatanika River. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1973-1974. Project F-9-6, 15 (G-II): pages 59-79.

APPENDIX A

Appendix A1.–Tentative sample schedule by date, sample area, and daily sample reach.

Date	Sample Area	Daily Sample Reach
May 19	Minto Flats	Cancer Slough/Minto Lakes
May 20	Minto Flats	Grassy Slough
May 21	Minto Flats	Chatanika and Tatalina rivers
May 22	Minto Flats	Rock Island Lake
May 23	Minto Flats	Sand Slough lakes
May 27	Minto Flats	Tolovana River mouth
May 28	Minto Flats	Grassy Slough
May 29	Minto Flats	Cancer Slough/Minto Lakes
May 30	Minto Flats	Chatanika and Tatalina rivers
October 1	Tanana River	Moose Creek to Chena River
October 2	Tanana River	Moose Creek to Chena River
October 3	Tanana River	Moose Creek to Chena River
October 6	Tanana River	Moose Creek to Chena River
October 7	Tanana River	Moose Creek to Chena River
October 8	Tanana River	Moose Creek to Chena River
October 9	Tanana River	Moose Creek to Chena River
October 10	Tanana River	Moose Creek to Chena River
October 13	Tanana River	Moose Creek to Chena River
October 14	Tanana River	Moose Creek to Chena River
October 15	Tanana River	Moose Creek to Chena River
October 16	Tanana River	Moose Creek to Chena River
October 17	Tanana River	Moose Creek to Chena River